Estimation of concrete compressive strength using advanced multivariate statistical techniques

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Abstract

This article deals with use of advanced multivariate statistical techniques for prediction of compressive strength of concrete using ingredients proportions. The parameters representing the concrete are normally highly correlated. Different multivariate statistical techniques appropriate for analysis of multicollinear data are discussed, and efficiency of stepwise regression in analyzing multicollinear data set was investigated. Principal component regression was used to analyse the multicollinear data and to build a predictive model of 28-day compressive strength of concrete. The efficiency of the proposed method is verified using an actual concrete mix proportioning dataset. Results indicated that principal component regression in very efficient in prediction of concrete strength using mix proportion data.

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Keywords: Concrete, Compressive strength, Estimation, Mixing, Multivariate.

1. INTRODUCTION

Concrete is one of the most widely used structural materials of construction industry. Traditionally, concrete has been fabricated from a few well-defined components: cement, water, fine aggregate, coarse aggregate, etc. The compressive strength of concrete is generally regarded as its most important property, and many other physical properties of concrete, such as elastic modulus, water tightness or impermeability are derived from concrete strength, as generally there exists a direct relationship between concrete strength and these parameters.

The compressive strength of concrete is many times greater than its tensile strength, and a majority of concrete elements are designed to take advantage of this higher compressive strength. Most often, an ultimate target in the mixture design is the 28th day compressive strength, which is usually determined based on a standard uniaxial compression test and is accepted universally as a general index of concrete strength. Other test ages are also used; however, it is important to realize the relationship between the 28-day strength and other test ages. Seven-day strengths are often estimated to be about 75% of the 28-day strength and 56-day and 90-day strengths are about 10% to 15% greater than 28-daystrength.

2. LITERATURE REVIEW

Researchers have used different approaches to derive a relationship between compressive concrete strength and mix proportion ingredients. Recently, most studies have been based on artificial intelligent techniques. Various authors have used a multilayer feed forward artificial neural network (ANN) trained by a back propagation algorithm (BPNN) to predict the compressive strength of concrete (e.g. [1,2,3,4,5,6]). Kim et al. (2005) have further enhanced the previously reported Kim et al. 2004 [6]. ANN using probabilistic neural network method to handle uncertainty [6]. Jain et al. (2005) commented on the work of Kim et al. (2004) and provided further insight into the implementation of neural network models for concrete mix [7]. Recently. Tesfamariam and Najjaran used adaptive neuro fuzzy inference system (ANFIS) to predict the compressive strength using mix design ingredients [8].

The main advantage of using ANN is their ability to model nonlinear relationships. However, the ANN models have often been criticized for being a black box. They do not provide a mathematical model of the problem, and the knowledge contained in an ANN model is maintained in the form of a weight matrix that is hard to interpret [7]. In the statistical literature, there exist the methods that are suitable for analysis of multicollinear data (e.g., concrete mix proportion data) and their potential in analyzing concrete mixtures